Rev. 0 — 5 October 2023 AN14070 **Application note**

1 Introduction

To help the customers get started with HSE on a S32G2 platform, NXP delivers the *HSE_DEMOAPP*, which is available for download from NXP's official website. This app-note explains in detail the steps to start the *HSE_DEMOAPP_S32G2XX_0_1_0_9* on *S32G-PROCEVB-S* Board. Besides, the app-note covers parts of *HSE_DEMOAPP_S32G2XX_0_1_0_9_ReadMe.pdf* that are relevant for successfully executing the *HSE_DEMOAPP* on the S32G2 hardware platform. The pdf is located at *<path> \HSE_DEMOAPP_S32G2XX_0_1_0_9*, where *<path>* is the local directory in which the demo is stored. So, for a more detailed description with different setups, it is recommended to refer to the pdf. Moreover, it is important to note that there are different versions of *HSE_DEMOAPP* for different S32 devices.

This app-note includes a few terminologies, such as sys_img, pink image and blue image. In addition, each of these terms are described in the *NXP HSE HIGH FW FAQ.pdf*. The pdf is located at the following location - <*path*>*HSE_DEMOAPP_S32G2XX_0_1_0_9*\demo_app\docs\.

Overview of steps involved.

- 1. Install the HSE_DEMOAPP_S32G2XX_0_1_0_9 on Windows PC.
- 2. Import the HSE demo project from HSE_DEMOAPP_S32G2XX_0_1_0_9 and generate an .elf.
- 3. Using S32DS IDE v3.5, create a new Application bootloader binary for M7 core of S32G2.
- 4. Generate a secure-boot blob image for M7 core by inserting a HSE pink image to the IVT.
- 5. Write the generated blob image to the target device's QSPI flash using S32 Flash Tool.
- 6. Load the generated HSE demo .elf to the SRAM using Trace32 Debugger Tool. .
- 7. Check the version and status of HSE FW.
- 8. Perform encryption and decryption. .
- 9. Verify the encrypted and decrypted results using an online AES Conversion Tool.

The following table shows the Acronyms used through out the document.

Acronyms	Definition
PC	Personal Computer
POR	Power On Reset
ROM	Read Only Memory
HSE	Hardware Security Engine
IVT	Interrupt Vector Table
IDE	Integrated Development Environment
FW	Firmware
AES	Advanced Encryption Standard
SRAM	System Random Access Memory

Table 1. Acronyms and definition



2 Installation

The following steps shows how to install the HSE_DEMOAPP_S32G2XX_0_1_0_9 on Windows PC

1. The HSE FW 0.1.0.9 SR Release for S32G2 can be downloaded from NXP.com. In case, the download is not permitted, please reach out to the NXP sales representative. After logging in, depending on the access right granted to the account, the user can find the packages listed under standard software offering, as shown in the following figure.

O Download He		es License Keys Notes	Files
6 Fil		v All Files	Show All
➡ File Name	File Size	File Description	+ File
MB LSE_DEMOAPP_S32G2XX_0_1_0_9.exe	14 MB	HSE_DEMOAPP_S32G2XX_0_1_0_9.exe	+ HSE
KB 📕 HSE_FW_S32G2XX_0.1.0.9_SCR.txt	1 KB	HSE_FW_S32G2XX_0.1.0.9_SCR.txt	+ HSE
MB HSE_FW_S32G2XX_0_1_0_9.exe	1.9 MB	HSE_FW_S32G2XX_0_1_0_9.exe	+ HSE
KB 🞍 HSE_FW_S32G2XX_0_1_0_9_Quality_Package.zip	22.7 KB	HSE_FW_S32G2XX_0_1_0_9_Quality_Package.zip	+ HSE
KB LSE_FW_S32G2_0.1.0.9_ReleaseNotes.pdf	247.5 KB	HSE_FW_S32G2_0.1.0.9_ReleaseNotes.pdf	+ HSE
tes	361 bytes	S32G2XX HSE Security Installer 0.1.0.9 SCR.txt	+ \$320

Figure 1. HSE demo download

- 2. From the HSE FW package, download the following files, the remaining ones are optional.
 - HSE_DEMOAPP_S32G2XX_x.x.x.exe
 - HSE_FW_S32G2XX_x.x.x.exe
- 3. After downloading them, consequently run *HSE_DEMOAPP_S32G2XX_x.x.x.x.exe* and *HSE_FW_S32G2XX_x.x.x.x.exe* and follow the instructions from the installation wizard.

A		
Name	Änderungsdatum	Тур
HSE_DEMOAPP_S32G2XX_0_1_0_9	25.05.2023 15:20	Dateiordner
HSE_FW_S32G2XX_0_1_0_9	24.05.2023 10:14	Dateiordner

Figure 2. HSE demo installation two

 After the installation is complete, navigate to the *<path>* to which the folder named HSE_DEMOAPP_S32G2XX_x.x.x.x is located – refer to above figure and open HSE_DEMOAPP_S32G2 XX_0_1_0_9_ReadMe.pdf, as shown in the following figure.

Name	 Änderungsdatum 	Тур	Größe
📜 demo_app	25.05.2023 15:20	Dateiordner	
hse_releases	25.05.2023 15:20	Dateiordner	
HSE_DEMOAPP_S32G2XX_0_1_0_9_ReadMe.pdf	11.04.2023 11:31	Foxit PDF Reader Do	9.061 KB
🖻 license.rtf	11.04.2023 11:33	Rich-Text-Format	526 KB
🞲 uninst.exe	25.05.2023 15:20	Anwendung	80 KB

- 5. Although, the HSE demo app supports multiple NXP platforms, the focus of this app-note is on S32G2. However, with some fine-tuning, the same steps can be mirrored on other listed target devices.
- 6. Furthermore, the HSE_DEMOAPP_S32G2XX_0_1_0_9_ReadMe.pdf does a deep-dive into the HSE_DEMOAPP_S32G2XX_0_1_0_9 package. The important highlights from the pdf are given below,
 - The section 5 and 6 detail the successful running of HSE FW using different resources.
 - The section 7 discusses ways to verify the status of the HSE FW, configure the relevant keys and services, perform different types of encryption and decryption on the target device. 322010932201093221.4.
- 7. Next, copy the subdirectories *hse* and *interface* from *<path>\HSE_FW_S32G2XX_0_1_0_9* to *<path>\HSE_DEMOAPP_S32G2XX_0_1_0_9**hse_releases\S32G2XX*, as shown in the following figure.

> OSDisk (C:) > NXP > HSE_DEMOAPP	_S32G2XX_0_1_0_9 > hse_releases > 9	532G2XX
Name	Änderungsdatum	Тур
📜 hse	25.05.2023 15:22	Dateiordner
🣜 interface	25.05.2023 15:22	Dateiordner
.keep	11.04.2023 11:31	KEEP-Datei
iaure 4. Copvina directories		

3 Load the HSE demo .elf to the SRAM

Import the HSE demo project from HSE_DEMOAPP_S32G2XX_0_1_0_9 and generate an .elf. The following steps shows how to import:

1. Once the installation of *HSE_DEMOAPP_S32G2XX_0_1_0_9* is complete, open the *S32DS v3.5* and navigate to *File -> Open projects from File Systems and Archives*. Next, from the dialogue box, click on *Directory* and navigate to *HSE_DEMO_S32G2XX*, as shown in the following figure.

Import source			Directory				
import source.			Di <u>r</u> ectory				
type filter text							
Folder	Browse for Folder						
	← → • ↑ 🖡 « de	mo_app > projects > S32DS	✓ Ü 2 sa				
✓ Close newly	Organisieren • Neuer	Organisieren * Neuer Ordner					
Use installed pr		Name	Änderungsdatum				
Search for n	🖈 Schnellzugriff		Anderungsdutum				
✓ Detect and ⊆		HSE_DEMO_S32G2XX	25.05.2023 15:29				
Working sets	oneDrive - NXP	HSE_DEMO_S32G3XX	25.05.2023 15:20				
	NXL27948	HSE_DEMO_S32R41X	25.05.2023 15:20				
Working sets:	3D-Objekte	HSE_DEMO_S32R45X	25.05.2023 15:20				
		HSE_DEMO_S32ZE	25.05.2023 15:20				
	Bilder	HSE_DEMO_SAF85XX	25.05.2023 15:20				
	Desktop	HSE_DEMO_SAF85XX	25.05.2023 15:20				

Figure 5. HSE demo project

2. The imported project will then appears in the Project Explorer window on the left-hand side.

How to Run HSE Demo Application on Cortex-M7 Core of S32G2



- Figure 6. HSE demo project two
- 3. After the project is imported, go to the *Project Explorer* window and navigate to *HSE_DEMO_S32G2XX/ src/services/src/main.c.* Though, the *main.c* file includes several functions that service HSE, for this specific use-case, the user may choose to simplify the code, as shown in the following figure.

int	main(void)
{	
`	HSE_MU_SendEvent(HSE_HOST_PERIPH_CONFIG_DONE);
	<pre>while(! CHECK_HSE_STATUS(HSE_STATUS_INIT_OK HSE_STATUS_RNG_INIT_OK));</pre>
	<pre>Init_Peripherals();</pre>
	HSE_GetVersion_Example();
	HSE_Status();
	HSE_Config();
	HSE_Crypto();
,	while(1);
3	

- Figure 7. Code snippet from HSE demo project
- 4. Additionally, as this app-note focusses only on *HSE_Aes_Example()*, the user may choose either to comment out or to remove the rest of the functions from *HSE_Crypto()*, as shown in the following figure.

```
void HSE_Crypto(void)
{
    ASSERT(CHECK_HSE_STATUS(HSE_STATUS_INSTALL_OK));
    HSE_Aes_Example();
}
```

Figure 8. Code snippet from HSE demo project two

5. It is important to note that if the above modifications are made to the original code, due to dependencies, the *srvResponse* will not return *HSE_SRV_RSP_OK* and therefore, the error handling will fail. Hence, it is necessary either to comment out or to remove the error handling, as shown in the following figures.

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```
/*----- AES ECB Encrypt Request -----*/
memset(testOutput_encrypt, 0, BUFF_LEN);
/* Send the request */
srvResponse = HSE_AesEncrypt(HSE_CIPHER_BLOCK_MODE_ECB, aesEcbKeyHandle,
   NULL, aesEcbPlaintext, aesEcbPlaintextLength, testOutput_encrypt);
/* Check response and output */
/*if( (HSE SRV RSP OK != srvResponse) ||
    (0 != memcmp(testOutput, aesEcbCiphertext, aesEcbCiphertextLength)) )
    goto exit;
}*/
/*----- AES ECB Decrypt Request -----*/
memset(testOutput_decrypt, 0, BUFF_LEN);
/* Send the request */
srvResponse = HSE AesDecrypt(HSE CIPHER BLOCK MODE ECB, aesEcbKeyHandle,
    NULL, aesEcbCiphertext, aesEcbCiphertextLength, testOutput_decrypt);
/* Check response and output */
/*if( (HSE_SRV_RSP_OK != srvResponse) ||
    (0 != memcmp(testOutput, aesEcbPlaintext, aesEcbPlaintextLength)))
ł
    goto exit;
}*/
```

Figure 9. Code snippet from HSE demo project three

The next step is to build the project. To do so, right-click on the project in the *Project Explorer* window and select *Build Project*. The *Build* action will *Compile* the project, *Link* the libraries and finally generate an *.elf*. The generated *HSE_DEMO_S32G2XX.elf*, as shown in the following figure and to be henceforth called HSE demo.*elf*, is located in the folder *<path>\NXP\HSE_DEMOAPP_S32G2XX_0_1_0_9\demo_app* *projects\S32DS\HSE_DEMO_S32G2XX\BuildConfig_Flash*.

Name	Änderungsdatum
📜 board	25.05.2023 15:30
🣜 generate	25.05.2023 15:29
Project_Settings	25.05.2023 15:29
📜 RTD	25.05.2023 15:29
src	25.05.2023 15:29
HSE_DEMO_S32G2XX.args	22.06.2023 16:48
HSE_DEMO_S32G2XX.bin	22.06.2023 16:49
HSE_DEMO_S32G2XX.elf	22.06.2023 16:49
HSE_DEMO_S32G2XX.map	22.06.2023 16:49
📄 makefile	22.06.2023 16:48
🗋 objects.mk	22.06.2023 16:16
sources.mk	22.06.2023 16:48
Figure 10. Generated .elf	

4 New application bootloader creation

Use of *S32DS IDE v3.5*, to create a new *Application bootloader* binary for Cortex-M7 core of *S32G2*. The following steps shows how to create:

 To create a new application bootloader .bin, first go to File -> New -> S32DS Application Project. Then, provided the relevant S32GX packages were installed, a list of processor will be displayed in the dialogue box. In case they were not, refer to the S32DS IDE v3.5 Installation Guide. Further, assuming that S32G274A is the target device, select the S32G274A_Rev2 Cortex-M7 processor from the list, as shown in the following figure.

type filter text	Core Kind	Name	Toolchain	
✓ ➢ Family S32G2	M7	Cortex-M	NXP GCC 9.2 for Arm 32-bit Bare-Metal	-
S32G2 Cortex-A53 Linux	M7	Cortex-M	NXP GCC 9.2 for Arm 32-bit Bare-Metal	1
S32G233A Cortex-A53 (decoupled mo	M7	Cortex-M	NXP GCC 9.2 for Arm 32-bit Bare-Metal	-
S32G233A Cortex-A53 (lockstep mode				
S32G233A Cortex-M7				
S32G234M Cortex-M7				
S32G254A Cortex-A53 (decoupled mo				
S32G254A Cortex-A53 (lockstep mode	Description:			
S32G254A Cortex-M7	GNU 9.2 To	olchain is sele	ected	^
S32G274A_Rev2 Cortex-A53 (decouple				
S32G274A_Rev2 Cortex-A53 (lockstep)				
S32G274A_Rev2 Cortex-M7				
> 😕 Family S32G3				
< >				\sim

Figure 11. Creating an application project

2. Although *S32G274A* has three M7 cores in lockstep, only one lockstep core is sufficient to perform the secure boot operation. Hence, for the purpose of this app-note, only *Cortex-M7_0* core is advised to be enabled – refer to the following figure.

Project Name	test_demo_M7_0		test_demo_M7_1		test_demo_M7_2	
Core	Cortex-M7_0		Cortex-M7_1		Cortex-M7_2	
Library	NewLib	\sim	NewLib	\sim	NewLib	\sim
I/O Support	No I/O	~	No I/O	\sim	No I/O	\sim
FPU Support	Toolchain Default		Toolchain Default	\sim	Toolchain Default	\sim
Language	С	~~	С	\sim	С	\sim
SDKs						
Debugger	S32 Debugger	\sim				
		-	1			

Figure 12. Core selection

3. Once these changes are incorporated, the user can customise the application bootloader code and subsequently, generate a *.bin* file. But, note that generating a *.bin* file is tricky. Unlike the *.elf* file, which is automatically generated post successful build, the generation of *.bin* file needs to be manually enabled. To enable it, first, right-click on the *<project> -> Properties*. Then, from the dialogue box click on *C/C++ Build -> Settings -> Tool Settings -> Create flash image*. Lastly, click on *Apply and Close* - refer to the following figure.

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4. The flash binary is, however, not yet created, because the final step is still pending. To create the flash binary, reopen the dialogue box, as shown in the following figure. Follow the same sequence until *Tool Settings*. And in the *Tool Settings* tab, expand the option *Standard S32DS Create Flash Image* and click on *General*. From the drop-down menu of *Output file format*, select *Raw Binary* and click *Apply and Close*.

Resource Builders	😻 Tool Settings 🎤 Build Steps 😤 Build Arti	fact 🗟 Binary Parsers 🧕 Error Parsers
✓ C/C++ Build	🖉 Cross Settings	Output file format (-O) Raw binary
Build Variables	Target Processor	Section: -i text
Environment	✓ Standard S32DS C Compiler	
Logging	🖉 Dialect	
Settings	Preprocessor	Other sections (-j)
Tool Chain Edi	Includes	
> C/C++ General	Optimization	
Project Natures	ඵ Debugging	
Project Reference:	🖄 Warnings	
Run/Debug Settir	🖄 Miscellaneous	
S32 Configuration	♥ Standard S32DS C Linker	
SDKs	👺 General	
Task Tags	🐸 Libraries	
> Validation	🖉 Miscellaneous	
	Shared Library Settings	
	🖉 Link Order	
	♥ Standard S32DS Assembler	
	🖉 General	
	Preprocessor	
	🖉 Debugging	
	✓ [™] Standard S32DS Create Flash Image [™]	
	🖄 General	
	✓ [™] Standard S32DS Print Size	
ure 14. Flash binary creation		

5. Then, rebuild the project as described in <u>Section 3</u>. The generated *<project_name>.bin* file will be located in the folder *<project_path>\Debug_RAM*\, as shown in the following figure.

How to Run HSE Demo Application on Cortex-M7 Core of S32G2

5 Secure-boot blob image generation

Generate a secure-boot blob image for Cortex-M7 core by inserting a *HSE* pink image to the *IVT*. The following steps shows how to insert the image:

- A blob image is a form of .bin file that, using a flash tool, is written to the storage device, such as a Flash, an eMMC or a SD card; in this case, the S32 Flash Tool is used to write the blob image to the QSPI Flash. Moreover, a blob image for S32G2 contains following components in the same sequence: a self-test DCD, self-test DCD (backup), DCD, DCD (backup), HSE, HSE (backup), application bootloader and application bootloader (backup). However, depending on the use case, one or more of the listed component could be left-out. Further, there is another critical part of the blob image called IVT that holds the pointers to the binaries of each of the enabled components. In addition to this, the secure-boot blob image includes a HSE pink image.
- 2. For creating a secure boot blob image for M7 core, the users can use the project created in step 3; note that it is not related to the HSE demo package, which was imported in step 2. So, once the required binaries are available, run S32DS IDE v3.5, then open the project that was either created in step 3. Next, switch the view from C/C++ to IVT, refer to the following figure.



3. The *IVTView*, shown in the following figure, displays the blocks *DCD*, *HSE*, *Application bootloader*, *Boot configuration* and *Automatic Align* that are relevant for the generation of the blob image.

IVTView [™]	
Boot Configuration	∩ ● On
Boot Target M7_0 +	
BOOTSEQ: Secured boot mode	Start address 0x110 Size in bytes 4
Boot Target Watchdog	
GMAC Generation	Reserved
Key Type Plain ADKP -	DCD (backup)
✓ Use new authenticated image format (only for S32G2 Rev2.1 and above)	Short address Out 18
Key File N/A	Start address 0x110 Size in bytes *
Life Cycle	• On 🔕
Life Cycle Keep existing configuration *	HSE
Interface selection	Start address 0x120
Boot device type QuadSPI Serial Flash 👻	
Configure QuadSPI parameters	HSE FW Configuration
QuadSPI parameters N/A	Reserved
IVT Image Address	HSE (backup)
IVT Image Start Address 0x0 💟	Start address 0x128
A	
	• On
Automatic Align Start Address: 0x0 Align	Application bootloader
Import IVT Image	
	Start address UX ISU Size in bytes 4

- Figure 17. IVT configuration
- 4. The DCD *.bin* contains the data that will be used to configure S32G2 after it comes out of reset. Moreover, the DCD is generally created using DCD Tool, but, in this case, the DCD *.bin* files are included in the demo project folder and can be directly loaded from *<path>NXP\HSE_DEMOAPP_S32G2XX_0_1_0_9\demo_app\images\S32G2XX_0_1_0_9\demo_app\images\S32G2XX_So,* from the four available binaries seen in the following figure, for general use-case load *dcd_init_sram.bin.*

Name	Änderungsdatum
dcd_init_sram.bin	11.04.2023 11:31
dcd_set_gpio25_and_init_sram.bin	11.04.2023 11:31
gspi_macronix_ddr_octal_dll_bypass_133Mhz.bin	11.04.2023 11:31
gspi_macronix_ddr_octal_dll_bypass_200Mhz.bin	11.04.2023 11:31

Figure 18. DCD binary image

5. Likewise, the HSE pink image is also delivered with the HSE demo project and is located in the folder <path>\NXP\HSE_DEMOAPP_S32G2XX_0_1_0_9\hse_releases\S32G2XX\hse\bin. However, before uploading the image, remember to modify its name from <image_name>.bin.pink to <image_name>.bin, as shown in the following figure.

Name	Änderungsdatum
rev2.0_s32g2xx_hse_fw_0.1.0_1.0.9_pb230405.bin	11.04.2023 13:35
rev2.0_s32g2xx_hse_fw_0.1.0_1.0.9_pb230405.bin.pink	11.04.2023 13:35
rev2.1_s32g2xx_hse_fw_0.1.0_1.0.9_pb230405.bin.pink	11.04.2023 13:35

Figure 19. HSE FW pink image

6. Moreover, as the sys-img is not yet available, disable the sys-img pointers in the HSE FW Configuration window, as visible in the following figure.

	HSE FW Configuration
Address 0x81000	SYS-IMG pointer
Size in bytes 45056	
Address 0x8d000	SYS-IMG pointer(backup)
Size in bytes 45056	

Figure 20. HSE FW configuration in IVT

7. Next, the Application bootloader image that was created in the step 3, is the third .bin that has to be linked to the IVT. Additionally, in the Application Boot Image block from the following figure, two addresses namely, RAM start pointer and RAM entry pointer must be populated in their respective fields.

▼ Application Boot Image
RAM start pointer Address
RAM entry pointer Address
Code length

Figure 21. Application boot code image configuration

8. Both the parameters can be found in the project's linker file with .Id extension. For S32G2XX target device, usually, the file name is S32G_M7_RAM.Id, as shown in the following figure.

¥ 😤	debug_demo_M7_0: Debug_RAM
>	🖑 Binaries
>	🔊 Includes
~	Project_Settings
	> 😂 Startup_Code
	> 🗳 Debugger
	✓ [™] Linker_Files
	B32G_M7_RAM.Id
>	🕮 include
Figure 22. Application code linker file	

9. To find the pointer addresses, scroll down S32G_M7_RAM.Id to the Memory section. Since, in this case, the 0th M core is in use, the RAM start pointer is 0x34001000, as shown in the following figure. Further, unless

an explicit mismatch is found in the *.bss* section of the linker file, the RAM entry pointer is the same as RAM start pointer i.e. 0x34001000.



Figure 23. Linker code snippet

10. Next, in the left-most panel of the *IVTView*, verify whether the *Boot Target* matches the core - here *M7_0*. In addition, before exporting the final secured boot blob image, make sure that none of the IVT fields are marked in red, as shown in the following figure. If they are, it indicates that an address overlap has occurred.

On Application bootloader C:\Users\nxt92049\workspaceS32DS.3.5\debug_demo\debug_demo_M7_0\Debug im im im im Start address 0x130 im Size in bytes 1896	0x130	Application bootloader - 3896 bytes Segment overlaps.	0x1067 (Reserved)
▼ Application Boot Code Image	0x138	Application bootloader (backup) - 4 bytes Segment overlaps.	0x13b

Figure 24. IVT automatic size alignment

11. The solution is to either recalculate the memory usage and manually add buffers between the conflicting memory segments or use the *Automatic Align* feature, as visible in the following figure, and simply click on *Align* button.

	Automatic Align	
Automatic Align Start Address: 0x0		Align

Figure 25. IVT automatic size alignment two

12. The last step is to export the blob image; please refer the following figure.

	Automatic Align Start Address: 0x0	
	Import IVT Image Export IVT Image	
	Import Blob Image	
	Export Blob Image Flash Image	
Figure 26. Export final blob image		

6 Writing the blob image to the QSPI flash

Use the *S32 Flash Tool* to write in the generated blob image to the target device's QSPI flash. The following steps shows how to write in the blob:

1. The blob image generated in step 4 needs to be delivered to the target device's QSPI Flash memory. Although, there are a few means to perform this task, this app-note discusses doing it serially using S32 Flash Tool and Trace32 Debugger. Moreover, the target device is S32G-PROCEVB-S Board and, with

corresponding modifications, can be replicated on other devices. Further, the S32 Flash Tool can be downloaded from NXP.com, provided the necessary access rights already exist. If not, reach out to the designated sales representative from NXP; note that the *Trace32 Debugger* is, however, a proprietary of *Lauterbach* and must therefore be purchased accordingly.

 Next, once the S32G-PROCEVB-S has entered serial boot mode and all the necessary prerequisites are fulfilled - refer sections 2 to 4 of AN12422 for detailed description, load the generated blob image, from step 4, serially to the S32G-PROCEVB-S Board. To do so, first find the COM port to which the target device is serially connected. To locate the COM port on *Windows OS*, open the device manager, go to *Connections* (COM & LPT) and look for USB Serial Port, as shown in the following figure.



Figure 27. Configuring serial communication port

3. Next, open the S32 Flash Tool, enter the COM port, perform Test connection check, set the device Target and choose the flash hardware Algorithm, as described in the following figure. Furthermore, the Upload target and algorithm to hardware. option uploads the algorithm linked to the target and QSPI flash device.

Simple View				
Initialization			Communication	
Select target and algorithm for uploading:			Select communication devi	ce and parameters:
Target S32G2xxx v 3.	Override XOSC frequency	40M 1 .	. • сом	
Secure serial bootloader:		Browse	Port name:	COM4
Algorithm MX25UW5124! 🗸 🕻 4.	V CS V		◯ CAN Bus	
Prepare target for Ethernet upload			Device name:	IXXAT
🖗 <u>Upload target and algorithm to hardware</u> 5.			Port number:	
			Serial number:	
riash operations			◯ Ethernet	
¹ <u>Upload file to device</u> 6.			Host:	
♣ Get flash ID		2	Stest connection	
Download from device		-		
Download from device to file				

Figure 28. Configuring S32 flash tool

4. Once the algorithm upload is complete, the log window displays a message confirming the successful deployment of the algorithm to the hardware – refer to the following figure.

	Execution	
	Program finished successfully.	
	Flash algo is loaded Device: Macronix MX25UW51245G	
	Capacity: 64 MiB (67108864 bytes)	
	<	
Figure 29. Binary image successfully loa	ded	

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5. Lastly, click on Upload file to device to upload the blob image. The log window will then display the progress of data-packets being transferred. Depending on the size of the HSE secure-boot blob image, the writing might take between a few seconds to a few minutes. After the successful loading of the blob image is complete, switch the mode from serial boot to QSPI boot – refer sections 4 to 6 of AN12422 for detailed description.

7 How to load the HSE demo .elf to the SRAM

Load the generated HSE demo *.elf* to the SRAM using *Trace32 Debugger Tool*. The following steps shows how to load in the blob:

- 1. In secure boot, immediately after POR, HSE M7 core executes the BootROM. The BootROM then reads IVT, loads its content into SRAM and after execution, passes the control over to HSE FW. So, once the target device is fully up and running, meaning the application code that was stored in the QSPI flash is loaded into the SRAM and, in this case, the M7 core has taken charge from HSE M7 core, the task then is to check the status of HSE FW and test a few of the HSE services. However, to begin with the HSE status check, the HSE demo .elf, that was generated in step 2, needs to be loaded to the SRAM; note that both the symbols and the code must be loaded. Also remember that this app-note uses Lauterbach's Trace32 PowerView for ARM as the debugging tool.
- 2. Next, connect the debugger probe between PC and the target device, run the executable and configure the *Debugger Tool*. Moreover, the initial configuration can be automated with the help of a *.cmm* file. So, to create a *.cmm* file, go to *File -> New Script*. Then, copy the below debugger-specific configuration code to it and close the script.

```
sys.CPU S32G274A-M7
core.ASSIGN 1.
sys.CONFIG.DEBUGPORTTYPE JTAG
SYStem.Option dualport on
SYStem.Option TRST OFF
SYStem.JtagClock 10MHz
sys.MemAccess DAP
ETM.OFF
```

3. Then, open the *Trace32 Debugger* tool and go to *CPU* -> *System Settings*. In the dialogue box, as shown in the following figure, verify whether the system parameters from the .cmm file, namely *CPU*, *dualport*, *DEBUGPORTTYPE*, *TRST*, *JtagClock* and *MemAccess* match.

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Figure 30. Configuring Trace32 debugger

4. Next, to attach to the running firmware, click on *Attach*; a green bar at the bottom-right corner of the GUI indicates that the attach was successful. After this, the HSE demo *.elf* file must be loaded. However, before loading the *.elf* file, pause the run by clicking on break, as shown in the following figure, or else the debugger will throw a *target running* error.



Figure 31. Trace32 debugger setting

5. Then, in the *command* bar, enter the command *data.list*. It displays the paused instance of the assembly code that was running on the M7 core - refer to the following figure.

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B::d.list						
► Step	H Over	🛃 Diverge	✓ Return	Ċ Up	► Go	II Break
add	r/line d	code	label	mnemon	ic	
ST:34	001A9C F	=04F30FF		mov.w	r0,#-0	x1
ST:34	001AA0 E	E7FB		b	0x3400	1A9A
ST:34	001AA2 🗄	3F00		nop		
ST:34	001AA4	LAC4		subs	r4,r0,	r3
ST:34	001AA6	3400		adds	r4,#0x	0
ST:34	001AA8 E	E7FE		b	0x3400	1AA8
ST:34	001AAA	0000		movs	r0,r0_	
ST:34	001AAC	35F8		push	{r3-r/	,r14}
ST:34	OOLAAE	3F00		nop	5	
S1:34		SCF8		рор	{r3-r/	}
ST:34				pop	{r3} m14 m2	
51:54		1770		hv	r14,r5	
ST.34	001480	+//0		bush	$\int r_3 - r_7$	r112
ST . 34		3510 3E00		non	(13-17	, , , , ,
ST-34		RCF8		nop	{r3-r7	3
ST:34	001ABE	3008		pop	{r3}	د د

Figure 32. Stepwise debugging using Trace32 debugger

6. Next, to load the HSE demo .elf, enter the command data.load <path to the HSE demo .elf>

N Step 😽 Ove	r 🎿 Diverge	🗸 Return	Ċ Up	► Go	II Break					
addr/lin	e code	label	mnen	nonic						
	Reset_Ha	Reset_Handler: /************************************								
	/* SK1p /******	//* SKip normal entry point as nothing /************************************								
13		cpsid i								
	14 CPSTA I									
ST: 3408042	0 B672	_start	: cpsi	d i						
ST:3408042 13 ST:3408042	0 8672 5 mov r 2 F04F0000	start 0, #0	: cpsi mov.	di wr0,#	¢0x0					
ST: 3408042 13 ST: 3408042 13 ST: 3408042	0 B672 5 mov r 2 F04F0000 6 mov r 6 F04F0100	start 0, #0 1, #0	mov.	d i w r0,# w r1,#	≠0x0 ≠0x0					

Figure 33. Stepwise debugging using Trace32 debugger two

7. Usually, the *.elf*, used for debugging and the blob image loaded to the flash originate from the same application code. However, here, they both originate from two different sources; *.elf* from HSE demo project and the *.bin* from an existing or imported M7 project. Therefore, this method is specifically devised for testing HSE with similar conditions; note that for a lean debugging experience in the *List* window, click the *Mode* button. The window then displays only the high level code, as shown in the following figure.

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Figure 34. Stepwise debugging using Trace32 debugger three

8. As the function calls necessary for executing the HSE services are in the *main()*, it is optimal to directly jump to that function and skip the initialization block. To do so, enter *go main* in the command bar. Moreover, from this point onwards, stepwise debug the HSE demo code. To do so, use *Step*, *Over* and *Up* buttons to step-into, step-over and step-up, respectively, as shown in the following figure.

► Step	H Over	🛦 Diverge	🗸 Return	Ċ Up	► Go	Break	🖾 Mode	60 t	Find:	ma
ado	dr/line s	ource								
	# 81 {	* ====== if define nt main(\	d(APP_HS oid)	E_FW_INS	TALL_NO	_SEC_BOOT)			
	82	HSE_MU	_SendEve	nt <mark>(</mark> HSE_H	IOST_PERI	PH_CONFI	G_DONE);			
۲	84	while(! CHECK_	HSE_STAT	US (HSE_S	TATUS_IN	IТ_ОК	HSE_STAT	TUS_RNG_I	NIT_OK));
	86	Init_F	eriphera	ls();						
	88_	HSE_Ge	tVersion	_Example	O;					
	90	HSE_St	atus();							
	92	HSE_CC	nfig <mark>()</mark> ;							
	94_	HSE_Cr	ypto <mark>()</mark> ;							
	96	while(1);							

Figure 35. Stepwise debugging using Trace32 debugger four

8 Status and version check of HSE FW

The following steps shows how to check the version and status of HSE FW:

1. The HSE_GetVersion_Example() on line 88 of <u>HSE services</u> contains the code that display's the HSE's FW version. However, to view the FW version, first open the serial terminal such as *PuTTY* on the PC, then configure the *COM* port and the *baudrate* accordingly, as shown in the following figure.

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🞉 PuTTY Configuration		?	×
Category:			
	Basic options for your PuTTY ses	sion	
	Specify the destination you want to connect	to	
Keyboard	Serial line	Speed	
Bell	COM4	115200	
Window	Connection type:		
Appearance	◯ SSH		~
Eisen 200 Osefinensier seriel seres la			
Figure 36. Configuring Serial Console			

 Moreover, before executing the code, either set a breakpoint on line 90 and click on Go or right-click on that line and select Go Till. Additionally, after execution, the parameters HSE FW Version and HSE FW Image is printed on the serial terminal. It must, therefore, be verified that the printed parameters on PuTTY matches the corresponding version number and image type – please refer the following figure.

81	int main(void)										
82	HSE_MU_SendEvent(HSE_HOS	HSE_MU_SendEvent(HSE_HOST_PERIPH_CONFIG_DONE);									
84	while(! CHECK_HSE_STATUS	<pre>S(HSE_STATUS_INIT_OK HSE_STATUS_RNG_INIT_OK));</pre>									
86	<pre>Init_Peripherals();</pre>	COM4 - PuTTY —									
88	HSE_GetVersion_Example(
90	HSE_Status();	HSE FW Version: 0.1.0_1.0.9 HSE FW Image: Pink									
92	HSE_Config();										
94	HSE_Crypto();										
96	while(1);										
	3										

- Figure 37. Code snippet displaying HSE_status()
- 3. Furthermore, the version can be verified against the last four digits of the installation folder name as shown in the following figure.

00	
	Name
	HSE_DEMOAPP_S32G2XX_0_1_0_9
	HSE_FW_S32G2XX_0_1_0_9

Figure 38. HSE version verification

4. The next check is the HSE FW's execution status and can be done by executing *HSE_Status()*. Since, the *Program Counter* must be on line 90, either set a breakpoint on line 92 and click on *Go* or right-click on that line and select *Go Till*. Then, verify the printed parameters against the corresponding status, as shown in the following figure.

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Figure 39. Code snippet displaying HSE_config()

5. Although, HSE_Config() does not play an active role in realising the objectives of this app-note, the function has some dependencies on HSE_Crpto() and therefore must be executed as well. Furthermore, the missing parameters HSE_STATUS_PRIMARY_SYS_IMAGE and HSE_STATUS_BACKUP_SYS_IMAGE in the above figure, indicate that as intended, the sys_img was not generated. Additionally, after this step, it is advised to leave the PuTTY window open, as it is used to verify the successful execution of step 8.

9 Encryption and decryption

The following steps shows how to perform encryption and decryption:

 After stepwise debugging until line 92, the next step is to verify the HSE cryptographic services on line 94 of <u>HSE_Status</u>. Moreover, as described in <u>Section 4</u> and seen in the following figure, *HSE_Crpto()* contains only one function i.e. *HSE_AES_Example()*. The function tests both encryption and decryption of the same plain-text; where, *aesEcbPlaintext* is the plain-text, *aesEcbKey* is the key and *testOutput_encrypt* and *testOutput_decrypt* is where the cipher-text and deciphered-text will be stored after encryption and decryption, respectively.



Figure 40. HSE AES example

2. The *aesEcbKey* and *aesEcbPlaintext* can be modified in the *hse_crpyto.c* source file. So, for simplicity, the key and the plain text were filled with 0x33 refer to the following figure. The user, however, may choose to insert a different combination.

Figure 41. HSE AES example two

3. In the encryption stage, *aesEcbPlaintext* is encrypted using *aesEcbKey* and the result is stored in *testOutput_encrypt*, as shown in the following figure.



Figure 42. HSE AES example three

4. Moreover, the *Watch* function of the *Trace32 Debugger* facilitates effortless monitoring of variables from the loaded .*elf.* So, to add a variable to the *Watch Window*, right-click on the variable and from the options select *Add to Watch Window* refer to the following figure.



Figure 43. HSE AES example four

5. The number 51, shown in the following figure, is the decimal value for 0x33.

Figure 44. HSE AES example five

6. Note that in order to change the variable's format in the *Watch Window*, right-click on the variable and select *Format* from the list of options, as shown in the following figure.

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- Figure 45. Configuring output window setting
- 7. In the decryption stage, the *testOutput_encrypt* is first copied to *aesEcbCiphertext*. Next, the cipher-text, using the same *aesEcbKey*, is decrypted and stored in *testOutput_decrypt*, as shown in the following figure.

H Step	Over	u Diverge	✓ Return	⊄ Up	▶ Go	II Break	Mode .	68 1		Find:		hse_crypto	.c	
ac	ldr/line	source												
/**/								^						
<pre>/* Send the request */ 620 srvResponse = HSE_AesDecrypt(HSE_CIPHER_BLOCK_MODE_ECB, aesEcbKeyHandle, NULL, aesEcbCiphertext, aesEcbCiphertextLength, testOutput_decrypt);</pre>														
		N	ULL, aesE	cbCipner	rtext, ae	SECOCIPN	ertextLe	ngtn,	tes	tOutput	_decryp	t);		
🕸 B::Va	r.Watch	N	ULL, aese	cbCipher	text, ae	SECOCIPN	ertextLe	ngth,	tes	tOutput	_decryp	t);		
& B∷Va	ır.Watch	N	VLL, aese	CDC1pher	text, ae h ≪Vi	ew X	ertextLe	ngtn,	tes	tOutput	_decryp	t);		

Figure 46. HSE AES example six

8. The parameter *HSE_Aes_Example* in the following figure indicates the successful execution of the *HSE_AES_Example()*.

💣 COM4 - PuTTY
HSE FW Version: 0.1.0_1.0.9 HSE FW Image: Pink HSE FW up and running! Status: HSE_STATUS_RNG_INIT_OK HSE_STATUS_INIT_OK HSE_STATUS_INSTALL_OK HSE_STATUS_CUST_SUPER_USER HSE_STATUS_PUBLISH_SYS_IMAGE HSE_Config: OK; Flash support: YES HSE_Aes_Example: OK

Figure 47. HSE Demo execution successful

10 Verifying encryption and decryption results

The following steps shows how to verify the encrypted and decrypted results using an online AES Conversion *Tool*:

- 1. The result from the encryption and decryption still needs to be verified. Moreover, this step will reveal HSE's capability in performing accurate AES based cryptographic conversions.
- 2. <u>Online AES Encryption and Decryption Tool (javainuse.com)</u> is one such online tool that is capable of executing cryptographic checks and can, therefore, be used for comparing the results. However, NXP does not endorse using any such tool.
- 3. Furthermore, for test purpose, *aesEcbKey* and *aesEcbPlaintext* were entered as key and plain-text, respectively refer to <u>testOutput_encrypt</u>. Moreover, the encrypted value of the cipher-text matched the *testOutput_encrypt* compare <u>testOutput_encrypt</u> with the below figure. Hence, it can be concluded that encryption carried out by HSE is accurate.

018713f227caeb2a890ce7437e943a63

Figure 48. Final result verification

- However, the verification of the decryption process was skipped, as the *aesEcbCiphertext* i.e. the ciphertext, for simplicity, was copied from the *testOutput_encrypt* and therefore, the decryption must return the original plain-text i.e. 0x33, 0x33,..., which it did.
- 5. Moreover, it is evident from figure 9.1 that the *testOutput_decrypt* matches *aesEcbPlaintext*. Therefore, proving that the decryption was also successful.

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